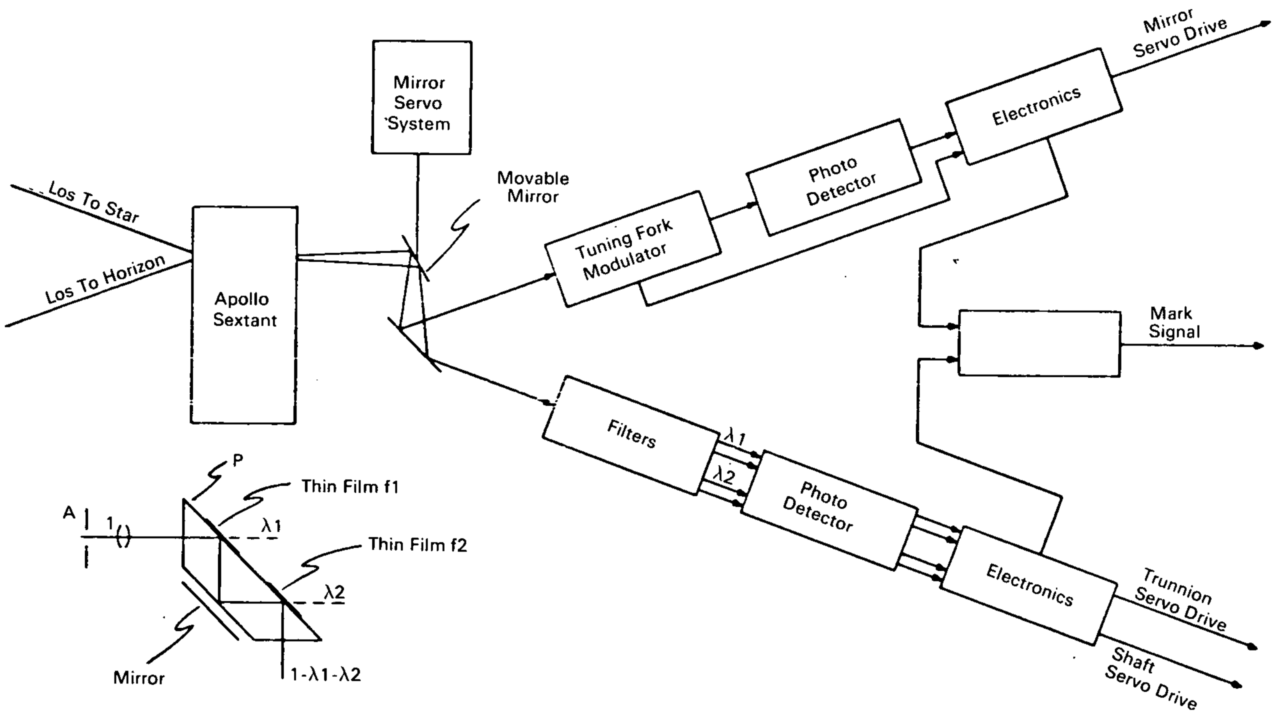
NASA TECH BRIEF

Automatic Star-Horizon Angle Measurement System



Schematic representation of star-horizon angle measurement system.

The problem:

To design an automatic star-horizontal (S-H) angle measuring aid for general navigational use.

The solution:

An automatic S-H angle measurement system in which an Apollo-type sextant is used. This system, which is still being developed, is shown schematically in the figure. Basically, the eyepiece of the sextant is replaced with a device having two light detectors and appropriate circuitry. The device automatically determines the angle between a navigational star and a unique point on the earth's horizon as seen from a spacecraft. The unique point is defined by a particular altitude above the earth's surface, and by the fact that the S-H angle is minimized.

How it's done:

To make a measurement, the eyepiece of the sextant is replaced by a unit containing two light detectors and associated circuitry. One detector would track the navigational star through the landmark line-of-sight

(continued overleaf)

while the other detector would track the earth's horizon through the star line-of-sight. This particular assignment of the lines-of-sight of the sextant allows the spacecraft to remain in a fixed inertial orientation, thereby minimizing fuel consumption. The lines-of-sight would be initially oriented by the on-board computer, and then the detectors would track the star and horizon by means of their respective servo systems. When tracking errors fall below a predetermined level, a mark signal is generated enabling the computer to record the S-H angle.

The star-tracking subsystem, which compensates for small angular motions of the spacecraft caused by limited cycling of the attitude control system, includes the rotatable mirror, tuning fork modulator, photomultiplier detector, associated electronics and the mirror servo-drive system (see fig.). Because the spacecraft has an attitude limit cycle of $+0.5°$, the star position would normally wander about within a $1° \times 1°$ box. Motion of the star in the $+y$ direction caused by the rotation of the spacecraft would be compensated for by the servoloop containing the rotatable mirror that limits the star position to the instantaneous field of view. Motion in the $+x$ direction activates a mark-inhibit whenever the star is more than a given distance from the y-axis.

The horizon-tracker subsystem, which locates and tracks a unique point on the earth's horizon, includes the light filters, photodetectors, and associated electronics as well as the trunnion-and shaft-servo systems of the sextant. This subsystem is based on a two-color, null-seeking horizon sensor in which the intensities of two different wavelengths of light emanating from the atmosphere are compared in such a manner that a null occurs at a particular altitude.

The S-H angle is determined when the errors of both the star tracker and the horizon tracker are below certain levels. At such time the on-board computer reads the trunnion angle of the sextant. The S-H angle is computed as the sum of the trunnion angle and the offset angle between the horizon and star trackers plus the correction factor for the curvature of the earth.

Notes:

1. This system could be of interest to those companies engaged in research and development of navigational systems for land, sea, and air vehicles.
2. Documentation is available from:
   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: TSP69-10597

Patent status:

No patent action is contemplated by NASA.

Source: D. Alexander Koso, Kenneth Koerber, and Paul C. Nardella of Massachusetts Institute of Technology under contract to Manned Spacecraft Center (MSC-11585)